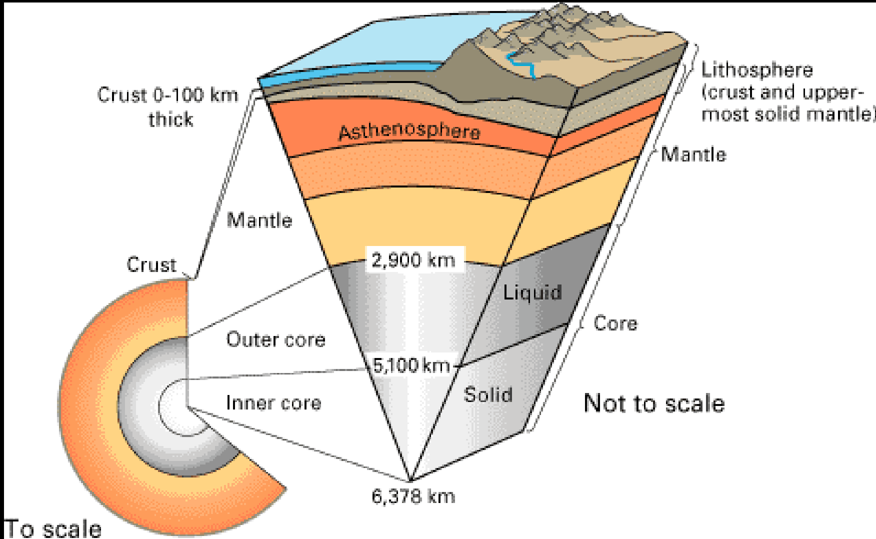
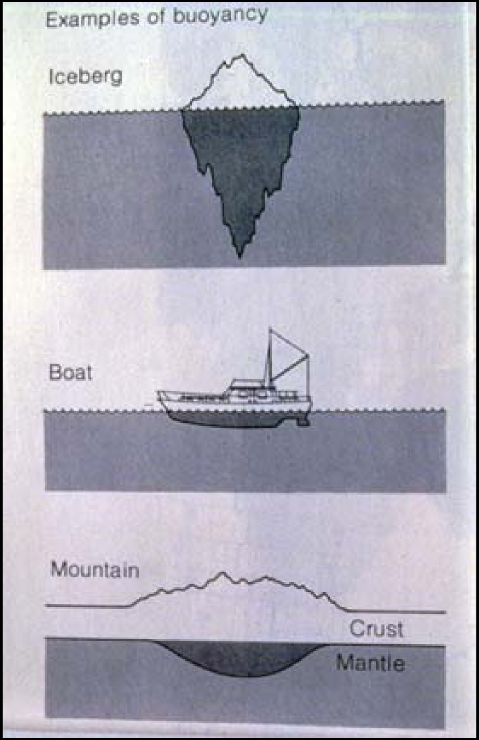
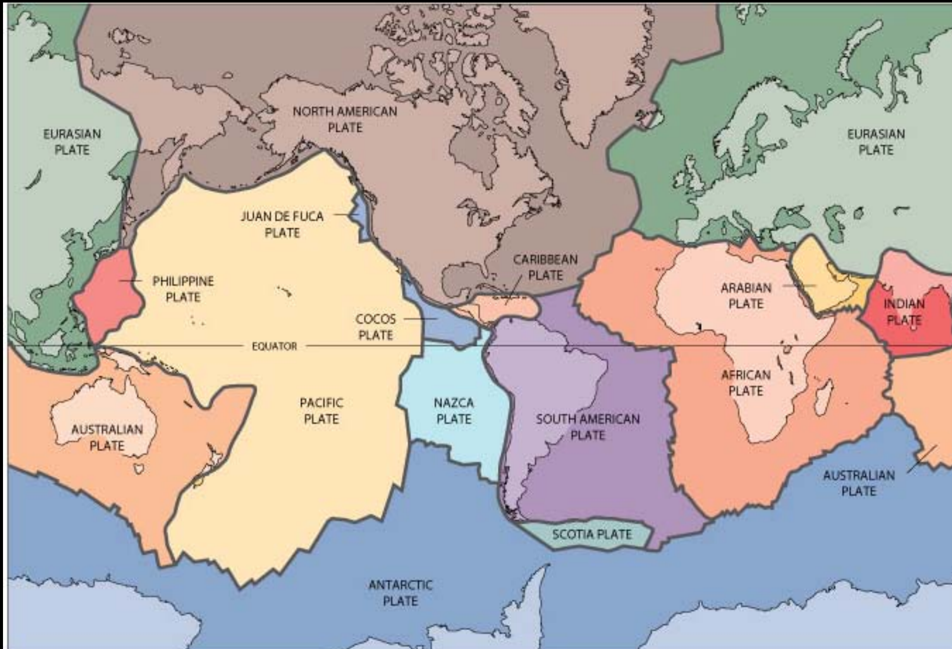
This program will look at the tremendous forces that shape the planet Earth and examine a theory that helps to explain how the geography of our planet has changed through time, in turn affecting climate and life. This theory is called plate tectonics. Tectonics, from the Greek word for “builder”, is the study of movement and deformation of earth's crust.



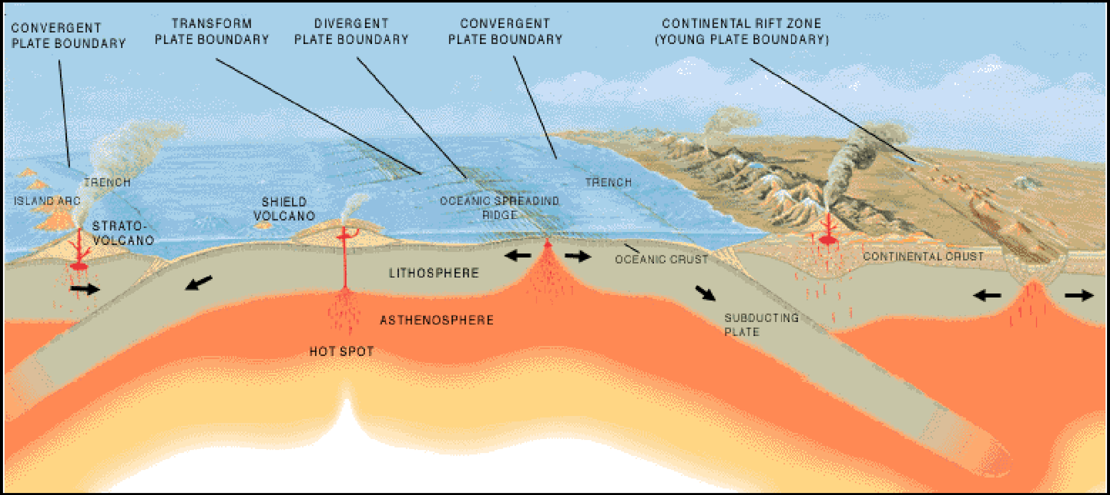
The theory is based on our knowledge of the inner structure of the earth. The earth is composed of concentric layers, with the outermost zone, the lithosphere (made up of the crust and the outer portion of the mantle), being relatively rigid. The underlying layer is called the asthenosphere. It is softer and has a yielding, plastic quality.



Because the lithosphere is less dense, it floats on the asthenosphere, like a boat.

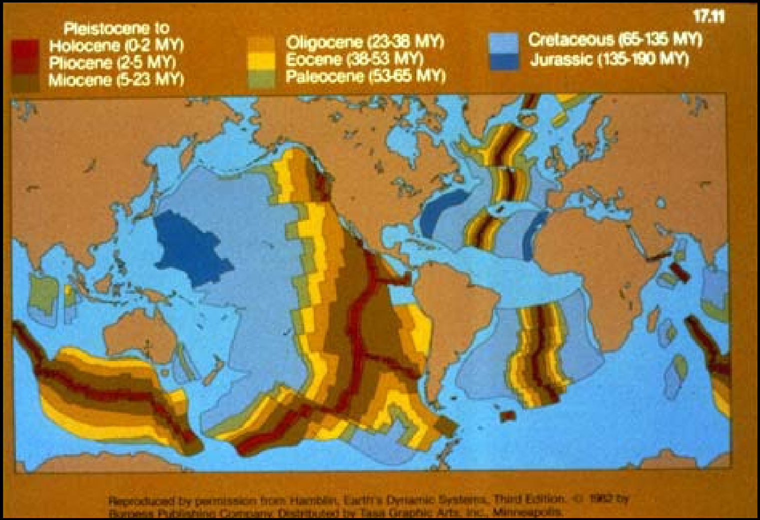


Another quality of the lithosphere is that it is not one solid piece but is composed of more than a dozen pieces, called plates, that fit together like the pieces of a jigsaw puzzle. These plates can move independently of one another and this movement is called continental drift. (Their movement can be compared to a conveyor belt, with the plates carrying along the continents, coral reefs, and volcanic islands.) The slow movement is powered by convection currents driven by tremendous heat from the earth's interior, and by the creation of new crust.



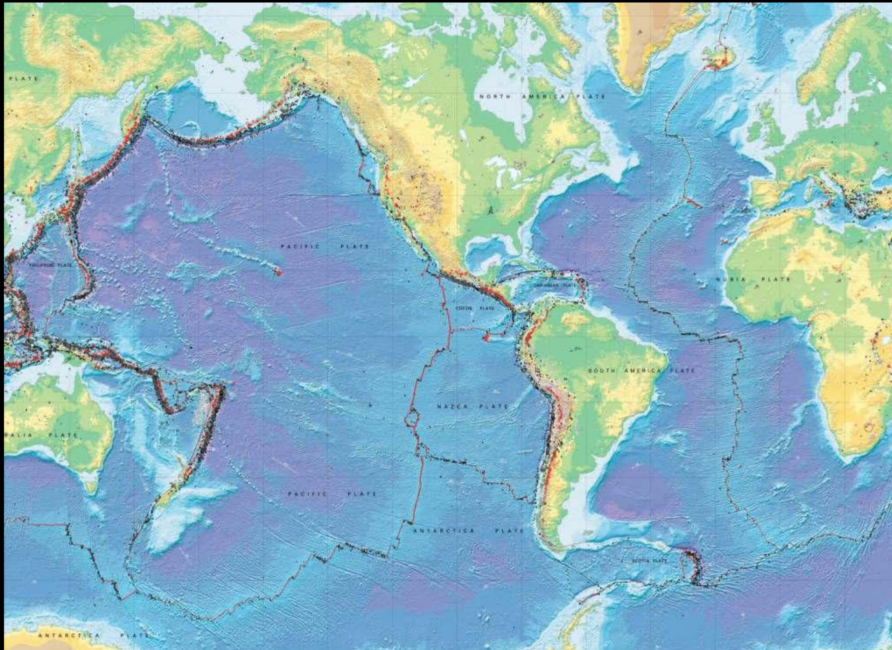
Our Changing Earth

New crust is created at the mid-ocean ridges (oceanic spreading ridge). The mid-ocean ridge is a series of mountain ranges that extends along the floor of the oceans and coincides with divergent (spreading apart) plate boundaries, where molten magma from the interior of the earth can escape. As the magma escapes, it cools and creates the mountains that form the mid-ocean ridge. For all the new crust that is created, some must be consumed. This happens at subduction zones (convergent plate boundaries), where plates are forced down into the inner recesses of the earth.



Our Changing Earth

The formation of new crust adds to the plates on either side of the mid-ocean ridge and results in sea floor spreading, in which the two plates slowly move apart. This slow spreading pushes on the "conveyor belt", moving along the plates and the continents they carry. The North American Plate is moving slowly northwestward at the rate of about 1 inch per year. Although this doesn't sound like very much, this process seems to have been in effect for the history of the earth, and over time has had a great effect on the movement and position of the continents. The colors on the map show the ages of the rocks that make up the ocean floor. The youngest rocks are those that are being formed at the mid-ocean ridge. As you move away from either side of the ridge, the rocks become progressively older because they formed earlier and have slowly moved away from the spreading center.



Our Changing Earth

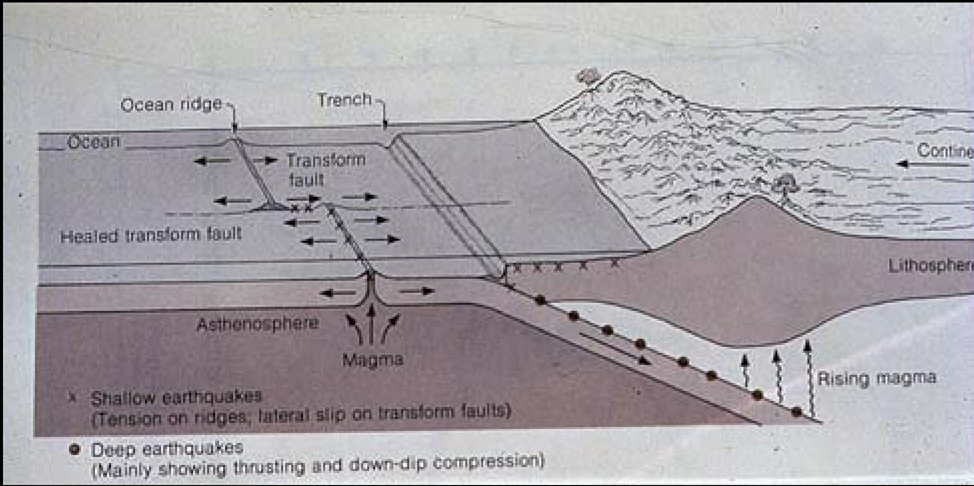
Besides having an affect on the physical location of the continents, plate tectonics accounts for the major geological features of our planet. This map shows some of the phenomena associated with subduction zones: volcanoes, earthquakes, and deep ocean trenches. The extremely hot temperatures of the inner earth causes super heated water and gasses from the subducting plate to rise, leading to a chain of chemical reactions that melts the mantle above the subducting plate. This melted rock is magma.

The extreme amount of magma associated with subducting plates rises to the surface and escapes through weak spots in the earth's crust, forming volcanoes.

Mt. St. Helens is only one of the many volcanoes that make up the "Ring of Fire"; a series of volcanoes associated with the subducting plates of the Pacific Ocean.

Volcanoes also occur at "hot spots". Hot spots are believed to result from rising plumes of heat within the underlying mantle. The Hawaiian Islands are an example of volcanic islands that rest on oceanic crust and they trace the movement of the Pacific plate over a hot spot.

The Islands were formed progressively as the oceanic crust moved over the hot spot and magma escaped to cool and form new land masses. Because of the progressive nature of this island formation, the Hawaiian Islands are consecutively older from southeast to the northwest.



Earthquakes are another consequence of sea floor spreading and the resultant subduction. They stem from the sporadic shifting of the subducting plate. As the plate subducts, it doesn't slide under smoothly but becomes hung up until the pressure builds. Transform faults occur when two convergent plates slide past one another in different directions.

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When the plate does finally move, the sudden release of energy causes an earthquake. This slide illustrates damage occurring from an earthquake along the San Andreas Fault, a transform fault.

Volcanic mountains are only one type of mountain formed from plate movement. While they are formed by subduction, other mountain ranges are formed by the collision of plates. Fault block mountains, like these in Grand Teton National Park, occur in places where the earth's crust has been broken up into large blocks by faulting. When crustal movement occurs from plate tectonics, some of the blocks are lifted or tilted while others sink.

Another type of mountain formed by plate collisions are folded mountains like these in Shenandoah National Park. Examples are the Appalachians and Himalayas. The force of the collision causes folding of weaker portions of the continental crust into arches and troughs. These mountain building processes explain how fossils of sea creatures can sometimes be found at the tops of mountains.

Our Changing Earth

When our earth changes its physical appearance, the climate changes too. Climate is affected by many different factors, such as latitude, altitude, proximity to large bodies of water and mountain ranges, and global weather circulation patterns.

Florissant Fossil Beds National Monument in Colorado is a case in point. Today Florissant lies at an elevation of over 8,000 feet and has a cool, dry climate. (The average temperature is 39 degrees Fahrenheit and the average precipitation is 15 inches per year.) The predominant vegetation is Ponderosa Pine interspersed with mountain meadows.

Our Changing Earth

In the Late Eocene, 35 million years ago, the climate and vegetation were quite different. There were several differences in the regional and continental geography that accounted for those differences. Because of continental drift, Antarctica and South America separated and the circum-Antarctica current developed. This changed worldwide oceanic circulation patterns and resulted in a worldwide cooling trend. Also, the North American Continent has been moving northwestward at the rate of about 1 inch per year. How far has it moved in the past 35 million years? (Colorado was about 600 miles southeast of where it is now).

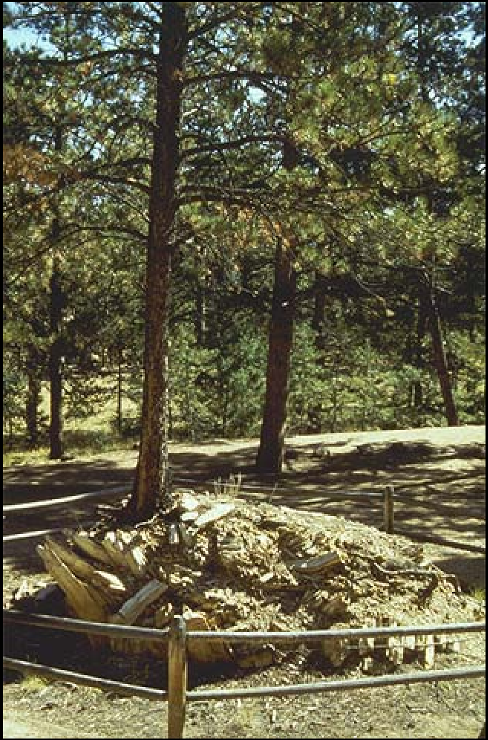
Also, at that time there were no major mountain ranges to the west of present day Colorado. Thus, there was nothing to block storms from the Pacific Ocean from carrying moisture to the area. Today, the coastal ranges, the Sierra Nevada and Cascades, block many of the moisture laden clouds, causing a rain shadow. The moisture falls on the western flanks of those mountains and results in a much wetter climate on the west side than on the east.

Our Changing Earth

There is evidence that plateau uplifts in the western U.S. (the Colorado Plateau) and Asia (the Himalayan Plateau) have resulted in a general global cooling trend in the past 40 million years. Although we may never know all the factors that have contributed to this cooling trend, we do know that the climate of ancient Florissant was warmer and wetter then. We can see this from the fossil record, which includes Sequoia trees and many types of hardwood trees that today grow in wetter, milder climates. Where do redwood trees grow today? How does geography affect their environment?

We know about these tremendous changes in the earth, in part, from fossils. While some of the dynamic processes on our earth, like volcanoes, have resulted in helping to preserve these clues to ancient life and climate, there are other natural processes that help to destroy them. 35 million year old petrified redwood trees are broken apart in a very, very small fraction of that time by freeze\thaw cycles in which water filling small cracks in the petrified wood is frozen and expands, pushing the wood apart.

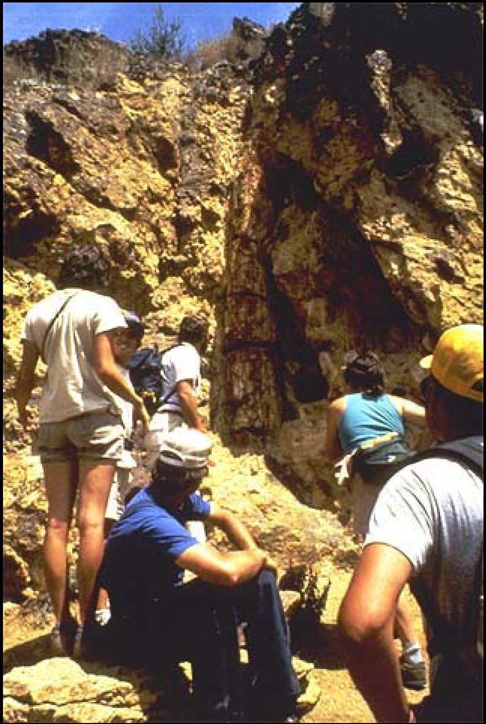
These stumps withstood the millennia until they were exposed to physical and chemical weathering by people who dug them up to show as a tourist attraction. Now they are deteriorating rapidly.



Continued weathering breaks down the petrified wood until it turns into soil and supports new life. The plants and trees that take root help to break down the stump even further, with their roots penetrating into the stump and breaking it apart as they grow.

The soil building process is a natural, ongoing factor in the deterioration of fossil resources. The "paper" shales of Florissant Fossil Beds break down very quickly once the overlying caprock deteriorates or is removed.

Erosion and landslides expose fossils to the elements.



While these natural processes are taking their toll, as in the example of Florissant Stumps, there are things that humans do that accelerate these processes that result in the deterioration and loss of fossil resources.

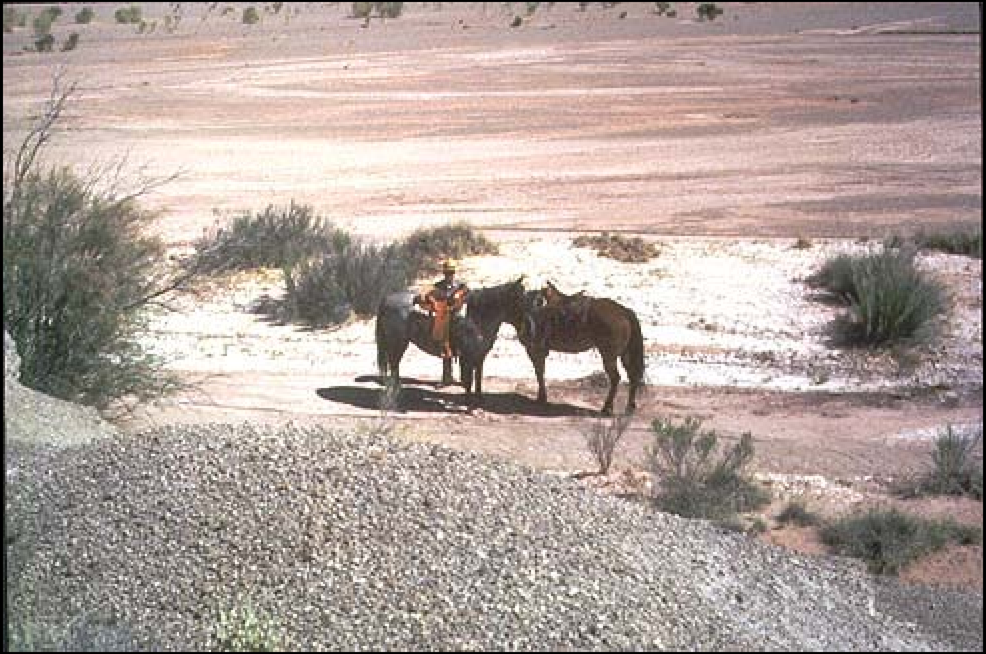
Digging fossils and taking them out of context without keeping good field records destroys millions of years of fossil information in a few minutes.

Something as seemingly harmless as off-road driving can result in erosion, causing fossil loss.

Once the Crystal Forest area in Petrified Forest National Park was covered with petrified wood. As you can see, it looks very different now. Through the years, people took away what may have seemed to be insignificant amounts of wood. But with time, it all adds up and now little remains.

The Park entry station is one place where the role of the National Park Service comes into play. The NPS is charged with preserving and protecting many of our national treasures, including some of the world's premier fossil sites. Informing visitors of the park rules and regulations is a first step in protection.

Through regular patrols, law enforcement rangers are able to prevent theft and vandalism of fossils.



Rangers on horse patrols of backcountry and wilderness areas can monitor fossil resources, noting any damage or vandalism.

The National Park Service is charged with preserving and protecting national treasures, and providing for visitor's enjoyment. This can be difficult because at times the Park's responsibilities toward preservation require limiting people's access.

Fossils are sometimes best preserved if they are underground where no one can see them. Display cases like this one, protecting the Daemonilix (Devils Corkscrew) at Agate Fossil Beds National Monument, are one way to protect fossils but still allow visitors to enjoy them.

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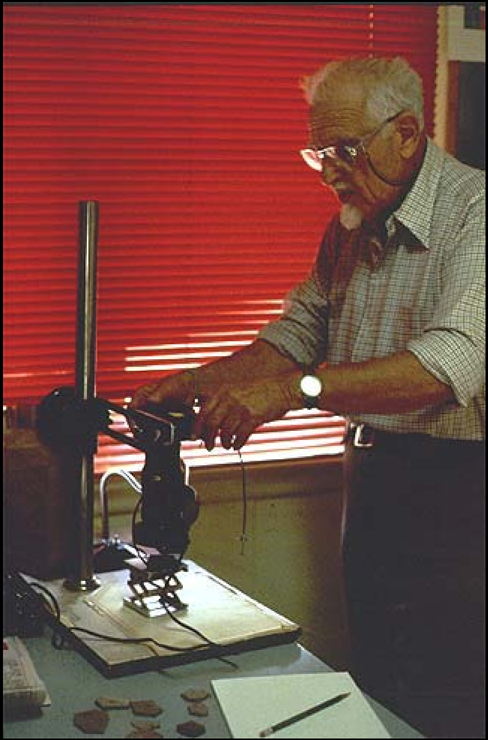
Attending an education program is another way visitors can learn about the chain of events leading to fossil formation.

Park Interpreters present the story that the fossils tell about the past and the ways in which each fossil site is unique. This knowledge helps visitors to understand why it is so important that fossils be protected, as the information they offer is irreplaceable.



Ongoing research by Park Staff and affiliated universities continues to provide new information about fossils and geology, and ensures that the visitors receive an updated version of the on going story of the past.

Our Changing Earth

This effort of the National Park Service to preserve, protect and interpret our fossil resources means that these valuable insights to the past can be appreciated by present and future generations.